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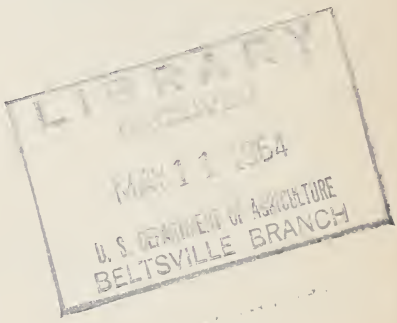
CULTURE AND UTILIZATION OF

Grain Sorghum



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CULTURE AND UTILIZATION OF GRAIN SORGHUM

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THE GRAIN SORGHUM CROP

Grain sorghums have been grown continuously in the United States for about 100 years. They were first grown successfully in Kansas in the 1880's. Now they are a major crop in the central and southern Great Plains and in the irrigated valleys of the Southwest. The average annual acreage harvested in the United States during the 10-year period 1947–56 was 8,382,000. The acreage increased to 19,503,000 in 1957 and was 16,761,000 in 1958. Average annual production for 1947–56 was 165,998,000 bushels; and the production for 1957 and 1958 was 564,324,000 and 614,845,000 bushels, respectively. Droughts in the 1950's that left soils too dry for fall sowing of winter wheat, government production controls, and the development of hybrid varieties influenced a shift to and an increase in grain sorghum production.

Three States, Texas, Kansas, and Nebraska, accounted for nearly four-fifths of the acreage and of the production in 1957 and 1958. Missouri, Oklahoma, California, Iowa, Colorado, New Mexico, South Dakota, Arizona, Arkansas, and North Carolina contributed most of the remaining acreage and production.

Grain sorghums belong to the grass family and are closely related to sudangrass, johnsongrass, and broomcorn. Formerly the grain sorghums in the United States were classified as milo, kafir, durra, feterita, and miscellaneous types. These terms have lost much of their meaning because the varieties grown in recent years are the result of hybridization and selection between these types. The term "milo" is popularly, though not accurately, used for the grain from colored-seed grain varieties.

ADAPTATION OF GRAIN SORGHUMS

Grain sorghums are grown chiefly where the seasons alternate between wet and dry. The crop is planted at the beginning of the rainy season and harvested during the early part of the dry period. A dry, warm period following maturation is necessary for drying the grain to assure safe storage. Such conditions also insure bright grain. The grain of most types of sorghum weathers badly and is often covered with a fungus growth when the weather is rainy or humid during ripening. Where most of the crop is grown, October and November are normally dry enough to insure good-quality grain. During a wet and humid fall, the crop can be harvested and stored safely if artificial dryers are used. Since about 1954 interest in growing grain sorghums in the

Corn Belt, where wet weather often prevails during the fall, has increased. In this region grain dryers are more readily available if needed.

Grain sorghums generally are considered superior to other crops in their ability to produce grain with a limited supply of moisture. In years of prolonged drought, the crop has the ability to remain "dormant" and renew growth when moisture conditions become favorable. However, the growth of the crop is retarded, and heads may not develop in time for the grain to mature before frost. Although this crop is considered to be drought tolerant and adapted to areas of low rainfall, it nevertheless responds as well as or better than most crops to adequate irrigation or rainfall. Yields in excess of 8,000 pounds per acre frequently are obtained with favorable moisture and fertility.

The grain sorghum varieties grown before about 1930 were adapted generally from Kansas southward through the southern Great Plains. Quick-maturing varieties developed since then can be grown in eastern Colorado, Nebraska, and central and southern South Dakota. The cooler summer temperatures of the northern latitudes delay development of the crop. Varieties that require only 55 to 60 days from planting to heading in Texas may require as long as 80 days in South Dakota. Soil temperatures of 70° F. or higher are considered best for germination and seedling growth, although some of the newer varieties become established at lower temperatures.

Grain sorghums can withstand greater extremes of heat than most other grains. They yield well in Arizona and California when the plants come into head during the hot summer months, but they yield best if planting is delayed so that the plants head when the hottest part of the season is past.

Grain sorghums grow successfully on all types of soil, but in dry seasons they do best on coarse-textured (sandy) soils. Fine-textured (heavy) soils produce a good crop in wet seasons, but the plants are liable to suffer from drought in dry seasons. Heavy soils are better suited to wheat production than are sandier soils, and in many areas wheat is grown on the heavy soils and grain sorghum on the sandy soils. Grain sorghums are among the crops that tolerate considerable quantities of alkali, or salts.

Grain sorghums when flooded are not so subject to drowning out as corn. However, grain sorghums habitually do not grow best under extremely wet conditions.

Chinch bugs sometimes limit production of grain sorghum in eastern Nebraska and Kansas and the central longitudes of Oklahoma and Texas. Varieties grown successfully in these areas are restricted to those that have the greatest tolerance to these pests. The sorghum midge limits grain sorghum production in southern Texas and the Southeastern States by destroying the developing grain.

Sparrows, starlings, blackbirds, and other birds often seriously damage grain sorghum fields. A few varieties, such as Darset and Combine Sagrain, are distasteful to birds. Losses can be minimized by growing large acreages or by planting a considerable distance from buildings and trees.

VARIETIES AND HYBRIDS

Before 1928 the grain sorghum varieties grew 4½ to 6 feet tall and some bore recurved heads. The types with recurved heads were headed by hand and were not suited to combine harvesting. In 1928, Beaver, a shorter variety with a straight head and therefore suitable for combining, was released; 2 years later Wheatland, another combine

variety, was released. Early Kalo, released in 1937, was grown widely in Kansas and Nebraska for a few years but lost its popularity because the crop often lodged before it could be harvested. Then, in 1941, a sturdy-stalked combine variety, Martin, was released; and combine sorghums increased in importance.

Other sturdy-stalked varieties, including Plainsman, Westland, Caprock, Midland, Combine 7078, Early Hegari, Dwarf Kafir 44–14, Redbine–60, Redbine–66, Combine Kafir–60, Darset, Redlan, Norghum, and Reliance, were introduced during the next few years. These varieties were the leading varieties in the Great Plains when grain sorghum hybrids were first grown on a field scale in 1956.

The first hybrid grain sorghum seed produced on a commercial basis was the result of a genetic 3-way cross. This system was discarded after 1956, and all hybrid seed is now being produced on cytoplasmic male-sterile seed parents. Hybrid grain sorghums outyield varieties of the same maturity by 20 percent or more.

Grain sorghum hybrids are designated by numbers rather than by name. State and Federal workers have adopted a uniform system of nomenclature for experiment station hybrids; the hybrids are assigned numbers based on maturity classes in relation to standard varieties, as follows:

Grain sorghum:	*Maturity group*
Earlier than Norghum	300
Norghum	400
Reliance	500
Martin	600
Plainsman	700
Dwarf Kafir 44–14	800

For example, if a hybrid has a maturity similar to that of Norghum, it is given a number in the 400 series; and if similar to Martin, a number in the 600 series. If at the time of its release the hybrid will be recommended in more than one State, the number is given a RS (Regional Sorghum) prefix. If the hybrid appears to be local in its adaptation, a prefix is given indicating the State which first distributes the seed.

Current lists of recommended varieties and hybrids are available upon request from the county agent in States where grain sorghums are grown.

SEEDBED PREPARATION

Good seedbed preparation is essential for good stands and weed control. Working the fields improves soil structure and aids in warming the ground. In dry areas of the Great Plains proper seedbed preparation conserves soil moisture.

In the Corn Belt and the South, the seedbed for grain sorghum is prepared in much the same manner as that for corn and cotton. The soil is turned with a moldboard plow and later tilled by disking and harrowing.

Grain sorghums are planted on fallow or after wheat or grain sorghum in the central and northern Great Plains. Tillage practices are the same in either rotation except that fallow ground needs an intermediate period of summer cultivation.

The best summer-fallow tillage methods store soil moisture and prevent soil erosion due to wind. Blades, chisels, one-ways, disk-plows, or rod-weeders may be used, as they leave some cover, a roughened soil surface, or both, for the winter months (fig. 1). Weed control on fallow is important so that moisture is not exhausted.

In the central and northern Plains, stubble fields commonly are undercut or one-wayed after small-grain harvest if grain sorghum is to be planted the following year. The stubble may be left standing to catch snow, which increases the stored winter moisture. The blade-type tools are operated at a depth

FIGURE 1.—Undercutting wheat stubble in preparation for next year's grain sorghum. Volunteer wheat and weeds are killed and plant cover prevents soil blowing. Rainfall and snow conservation will be high.

of 5 to 7 inches, which leaves the plant residues intact. One-way diskplows do not cut so deep and they function best in years of abundant rainfall, when plant growth is heavy and recurring. In dry years they tend to destroy the vegetative cover and pulverize the soil.

Sometimes land is chiseled in preparation for planting grain sorghum. Chisels break up the soil to a depth of 8 to 12 inches or more and are often used when wind erosion is troublesome during the winter and early spring. The moldboard plow is almost always used for seedbed preparation in the central and northern Great Plains on irrigated land.

Fallowing is not practiced on most of the southern Great Plains, because moisture evaporation is high and the sandy soils have a limited water-retention capacity. Grain sorghum often is grown in rotation with cotton, usually following small grains. One-way disking is the common initial soil preparation on dry land. Irrigated land usually is tilled with a moldboard plow.

Much of the grain sorghum in the Great Plains is grown by continuous cropping.

The land may need tilling two to four times before planting grain sorghum. Frequent tillage is necessary when the spring is wet as weed growth is rapid. The destruction of weeds is vitally important to avoid competition with the crop. Grain sorghum seeds often germinate rather slowly, and the seedlings are too small to compete with weeds successfully until about 4 weeks after planting. Soil moisture loss by surface drying may be excessive in dry spring weather, but usually fewer weeds grow when the soil is dry. In much of the Great Plains, land is tilled in the spring with the hope of getting a rain before planting.

FERTILIZERS

Grain sorghum has a reputation of being hard on the land. It is a

heavy feeder of nitrogen, but any high-yielding grain crop is soil-depleting. It is best for grain sorghum to follow wheat in the rotation rather than precede it in the Great Plains; and, if grain sorghum is grown in the Corn Belt, substitute it for corn in the basic corn-oats-meadow rotation. Grain sorghum responds to phosphatic fertilizers in many soils. Potash deficiencies are less except in the Coastal Plains States. Fertilizers are commonly used in areas where cotton is grown, and their application to grain sorghum is considered routine. Fertilizers are also generally applied to irrigated grain sorghum; 40 to 80 pounds of actual nitrogen per acre is usually used.

Grain sorghum ordinarily does not respond to fertilizers under dryland farming on the heavy productive soils of western Kansas, western Nebraska, and eastern Colorado except in wet years. In these areas rainfall is the primary limiting factor in crop production. An application of 800 pounds per acre of complete fertilizer is recommended for some soils of low fertility in the Southeastern States, where rainfall is high.

An adjacent high concentration of fertilizer may injure germinating seeds. Therefore, place the mixed fertilizers a little to the side and a little below the seed row.

Nitrogenous fertilizers are the most commonly applied. Application before planting, banding at planting, sidedressing at cultivation, and inclusion in irrigation water have been used successfully. However, all fertilizers are most effective when they are applied to young and actively growing plants. Late applications seldom result in response.

Besides mixed or chemical fertilizers, barnyard manure is often available for spreading on fields to be planted to grain sorghum. Sewage sludge or plant-waste byproducts can be used to advantage if the price is reasonable. If you use one of these materials, work it into the soil with the initial tillage.

Because of extreme variation in the fertility of soils and in the rainfall, no general recommendations for fertilizers are made. Obtain this specific information from your county agent or the State agricultural experiment station. In general, the fertilizer practices suitable for corn are favorable to grain sorghum in the particular area.

SEED SELECTION AND TREATMENT

Seed Selection

Grain sorghums are not a completely self-fertilized crop, and they cross readily with other grain and forage types and with sudangrass and johnsongrass. They also mutate, or spontaneously produce off-type tall plants commonly seen in the field. For these reasons plant only seed of known quality and purity. The cost of high-quality seed is not important in the production of grain sorghum, because so little is planted per acre.

Certified varieties and hybrids must meet certain field standards of isolation and roguing before pollination and laboratory standards of high germination, freedom from weed seeds, and a minimum content of foreign matter or other crop seed. Purchase seed from commercial distributors on the basis of the reputation of the producer or company. Most commercial seedsmen follow practices equal to those of the certified producer.

Though a small percentage of off-types and outcrosses do not materially reduce the yield of a field of grain sorghum, they are unattractive and they reflect standards of seed production. Outcrosses to "wild canes" and sudangrass may create a weed problem. Outcrosses to johnsongrass usually are not seri-

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ous, for most of the hybrids are sterile and produce rootstocks less vigorous than johnsongrass. They do not appear to overwinter in areas north of southern Kansas.

For the reasons indicated, it is desirable to purchase new seed of varieties each year. It is mandatory to buy new hybrid grain sorghum seed, because of the genetic breakdown, or segregation, that occurs the second year. This is accompanied by a decrease in yield.

Seed Treatment

Treat all seed of grain sorghum with a fungicide before planting to protect it from soilborne organisms that cause seed decay or that attack the young seedlings. Thus, stands are improved by higher germination, and greater seedling vigor may result in higher yields and improved crop quality. Seed treatment also controls the kernel smuts of grain sorghum, but it does not control head smut.

Fungicides can be applied as dusts, slurries, or liquids. Most farmers prefer dust methods because less equipment is necessary, but the slurry method is becoming increasingly popular with commercial treaters. Dust treatments are more irritating to the respiratory system of the applier.

Seed-treating materials generally are classed as mercurial or nonmercurial.[1] Nonmercurials have been used more widely and in general are preferred for treating grain sorghum seed, but they must be applied more thoroughly as they are nonvolatile. Danger of overtreating is less with the nonmercurials.

Nonmercurials[2] recommended for treating grain sorghum seed include thiram (marketed as Arasan 75, Panoram 75, and Thiram), dichlone (marketed as Phygon), chloranil (marketed as Spergon), and captan (marketed as Orthocide 75). Apply them either as dusts or as slurries.

Mercurial compounds[2] that can be used for grain sorghum as dusts or slurries are: Ceresan M, Agrox, and Puraseed. Satisfactory liquid mercurial compounds are: Panogen 15, Panogen 42, MEMA, Setrete (also marketed as Gallotex and Mersol), and liquid Ceresan (marketed as Ceresan 75, Ceresan 100, and Ceresan 200). Mercurial compounds are recommended for treating grain sorghum seeds with persistent glumes. Viable smut spores may lodge beneath these glumes and thus escape treatment if nonmercurials are used.

Combination fungicide-insecticide treatments have been used successfully. These control not only seedling diseases and kernel smuts but also insects that attack the seed, such as the wireworm and the thief ant (kafir ant).

Nonmercurial fungicide-insecticides[2] include combinations of captan-dieldrin (marketed as Captan Dieldrin and Orthocide Dieldrin) and thiram-dieldrin (marketed as Delsan A–D and Panoram D–31). A liquid mercurial fungicide-insecticide combination of Panogen and Drinox (aldrin) has been satisfactory, but there is greater danger of overdose when mercurial compounds are used.

DATE OF PLANTING

Soil temperature mainly determines when grain sorghum should be planted. Being semitropical in origin, it should not be planted until the soil warms in the spring to near 70° F. at the planting depth and there is little chance of subsequent lower temperatures.

Most of the grain sorghum in the central Great Plains is planted be-

[1] For more detailed recommendations, see U.S. Dept. Agr. Misc. Pub. 219, Treat Seed Grain.

[2] The mention of trade products does not imply their endorsement by the U.S. Department of Agriculture over similar products not named.

tween June 1 and June 20. This area extends from South Dakota into Texas and from the Corn Belt to the Rocky Mountains.

Planting begins about February 25 in the Coastal Bend of Texas and is progressively later toward the north, with the bulk of the crop in the High Plains of Texas and New Mexico being planted in June. Late plantings of quick-maturing varieties are successful up to July 15 in the southern Plains. A fall crop sometimes is planted under irrigation in the lower Rio Grande Valley of Texas, but early frost may damage it.

Relatively early planting is desirable where chinch bugs are abundant. Much planting is done in late April in north-central Texas, early May in central Oklahoma, and late May in eastern Kansas and Nebraska because of the prevalence of chinch bugs. Such early planting reduces chinch bug damage, but poor stands may result.

In the irrigated areas of southern Arizona and southern California, where high temperatures in midsummer affect growth and pollination, most of the grain sorghum is planted in July but some is planted early, usually in April. A small acreage of grain sorghum is planted under irrigation in central Washington from May 20 to June 10.

In the South planting dates range from April to early July. The late planting often follows small-grain harvest, which provides two grain crops in one season. Successful midsummer plantings in the South largely depend on favorable soil moisture. The sorghum midge is more likely to damage later plantings in this region.

The hegari group of grain sorghums is especially sensitive to day length. For a grain crop, Hegari, Early Hegari, and Combine Hegari are planted in February or March or after August 15 in southern Texas. For a forage or dual-purpose crop, Hegari is planted in May or June in southern Texas and in the rolling and southern Plains. Early Hegari matures early when planted after June 20 on the High Plains or during early June in the States to the north.

Although the day length during the first 5 weeks after planting largely determines heading, it is essential to plant the later maturing types in the early part of the recommended planting season and the early types later. This practice promotes more normal growth of both types. As a general rule, plant the latest maturing variety or hybrid that will mature in the normal growing season. Then, if the stand fails, replant with an earlier maturing type.

METHOD OF PLANTING

Grain sorghums are planted either in rows spaced sufficiently far apart to be cultivated or in close-spaced rows if cultivation is not intended. Row-crop planters for corn or cotton can be used for grain sorghum when equipped with suitable seed plates. In the Great Plains, small-grain drills with some of the planter holes closed are also used.

Planters designed especially for grain sorghums have come into use (fig. 2). Many of these are modified listers, and some are equipped with furrow openers in front. The ridges are not so high with these as with conventional listing. However, where low soil temperatures prevail, surface planting is generally superior to lister planting. In the drier soils, rubber wheels located immediately at the rear of the planter press the seed into the ground and thus improve the stand.

Many older planters space rows 40 or 42 inches apart. However, machinery having planter units that are easily moved on a tool bar is available; this allows closer spacing of rows. Closer spacing of rows

FIGURE 2.—Planting grain sorghum with a loose-ground, furrow-opener planter. This machine has many of the advantages of both surface planting and listing.

and placing seeds farther apart in the rows provide a more uniform feeding area around each plant. Grain sorghum planted in rows 20 inches apart usually produce more grain than that planted in rows 40 inches apart, with the same number of seeds per acre. Reduced evaporation of water from the soil or more efficient use of water, nutrients, and light accounts for the higher yield. In the drier areas, especially, it is important to plant the same number of seeds per acre in close-spaced rows as would be desirable in plantings with row spacings of 40 or 42 inches.

Grain sorghum seed is small; consequently, do not plant it too deep. If the soil is loose and moist, plant 1 inch deep; but if it is dry and hard, plant about 2 inches deep. The soil immediately around the seed should be firm in order to obtain rapid moisture absorption, germination, and emergence. Planting in the bottom of a furrow may be hazardous when rains and subsequent soil crusting follow, but it is advantageous when dry weather ensues. The soil in drill-planted fields, likewise, may crust after heavy rains.

RATE OF PLANTING

Overplanting causes most of the production failure in much of the main Grain Sorghum Belt. Farmers often overplant because they obtained a poor stand the preceding year. Poor stands may be due to poor seed, improper planting methods, poor seedbed preparation, and occasionally crusted soil resulting from rain following planting. Good cropping practices can do much to alleviate all these problems except the last.

A pound of grain sorghum generally contains 13,000 to 22,000 seeds. Under good seedbed conditions about 50 percent emergence can be expected. Table 1 gives the approximate number of seeds per foot of row for various seeding rates and seed sizes.

TABLE 1.—*Relation of seed size to planting rate in rows 40 inches apart*

Planting rate (pounds per acre)	Seeds per foot of row for varieties that contain—				
	13,000 seeds per pound	16,000 seeds per pound	18,000 seeds per pound	20,000 seeds per pound	22,000 seeds per pound
	Number	*Number*	*Number*	*Number*	*Number*
2	2	2	3	3	3
4	4	5	6	6	7
6	6	7	8	9	10
8	8	10	10	12	13
10	10	12	14	15	17
12	12	15	17	18	20
14	14	17	19	21	24
16	16	20	22	24	27

Use the same rate of seeding per acre with row as with drilled plantings. Low rates of planting are not possible with some grain drills, but many of the more modern drills have slow-speed settings. Grain sorghum has a great capacity to tiller, or "stool," under good environmental conditions. This often compensates for a stand deemed only mediocre at emergence. Hybrids appear to have a tillering capacity as great as do varieties.

A proper rate of planting is equally important on dry land and irrigated land. Overplanting on dry land can mean crop failure, and underplanting on irrigated land can mean a reduced yield. Growth response of the grain sorghum plant differs slightly with the thickness of the stand. With a thick stand there is little tillering and the heads and stalks are small. Small heads and stalks put less strain on the combine when harvesting and are preferred by many machine operators. The plants also grow taller when close together if a shortage of soil moisture or fertility does not stunt them.

Planting rates on nonirrigated land range from 1½ pounds per acre in the drier areas of the western Great Plains to 8 pounds in the more humid regions, such as the Coastal Bend of Texas, the Corn Belt, and the South. Reduce planting rates in regions with abundant rainfall if soils of low fertility are not fertilized. In the Great Plains, where most of the dryland grain sorghum is grown, a planting rate of not more than 4 pounds per acre is recommended. A 2-pound rate is normally adequate.

Heavy planting rates are desirable under irrigation. To obtain a sufficiently high plant population without excessive crowding in the row, it is necessary to plant in relatively close-spaced rows. With most varieties, 8 to 10 pounds per acre are recommended; but, with large-seeded varieties, as much as 16 pounds may be necessary. Populations of 100,000 to 120,000 plants per acre in close-spaced rows combined with good agronomic practices, such as sufficient water and fertilizer, result in highest yields.

CULTIVATION AND CHEMICAL WEED CONTROL

Cultivation

The most important reason for cultivation of a row crop is to control weeds. Do not cultivate deeply and cultivate only as often as necessary because excessive and deep cultivation can cause serious damage to the plants from root pruning.

FIGURE 3.—First cultivation of a grain sorghum field with an ordinary corn and cotton cultivator. At this cultivation soil is thrown away from the young plants; at the next cultivation soil will be mounded around the crowns.

Cultivation with ordinary corn and cotton cultivators can be done most easily in rows 40 or 42 inches apart (fig. 3). Closer spaced rows can best be tilled with special field cultivators or equipment for sugarbeet cultivation. Mound the soil around the crowns, particularly at the last cultivation, to reduce root lodging. Planting in shallow furrows will aid in this operation.

Much grain sorghum planted with a grain drill has no post-planting cultivation. However, weed-free fields are possible only under the most ideal conditions.

The rotary hoe is used widely as a cultivating tool on drilled plantings. It is not particularly adapted to furrow plantings unless modified to run in the furrow trough. A rotary hoe kills small weeds; it also helps in breaking crusted soil, which aids in emergence.

Chemical Weed Control

Chemical control of weeds in grain sorghum is not a substitute for mechanical cultivation but can be used in conjunction with it. The most frequently used compound is 2,4–D. It effectively controls most broadleaved weeds when they are small, but it does not control grassy weeds.

Grain sorghum is susceptible to 2,4–D damage. Apply 2,4–D when the plants are 4 to 12 inches tall but before the boot stage, as they are not so susceptible at that stage of growth. Usually, apply 2,4–D when the weeds are small, as the grain sorghum plant will not tolerate the large dosage required to kill large weeds.

The extent of weed infestation, size of the weeds, and size or development of the plants determine the rate of application. Suggested rates of 2,4–D acid equivalent are ¼ to ⅓ pound of an ester or ⅓ to ½ pound of an amine salt formulation per acre. As a rule, apply as little 2,4–D as will control the weeds. Place the spray nozzles near the ground so that the grain

sorghum leaves will receive as little of the spray as possible. However, it is often difficult not to get the chemical on the plants because weed infestation is most serious when the crop is small.

Symptoms of 2,4–D damage are lodging, brittle stalks, stunting, height variability, head sterility, and yield reduction.

IRRIGATION

Grain sorghum is a drought-tolerant crop, but it responds well to favorable moisture conditions. Often yields of 6,000 to 8,000 pounds per acre result with optimum moisture, fertility, and population.

Irrigate before planting on soils with deep profiles whenever the cropping system allows it. Wetting to a depth of 6 feet is recommended in the High Plains of Texas and New Mexico and in the Salt River Valley of Arizona. Limited water supplies are used most efficiently in this manner. In experiments, grain sorghum utilized moisture from a 90-inch depth when the field was wet to field capacity to 7 feet at planting time and no supplemental irrigation water was applied.

Most growers irrigate only two to four times after planting. Intensive cropping systems require high water-application rates. Four inches of water usually can be applied at one time to many medium- and fine-textured soils, but percolation is usually too high on coarse-textured soils for such heavy waterings.

Timeliness of watering during the growing season is important. The plant requires the most water at the booting and heading stages. Watering is essential before this period of heavy water usage. A few heavy waterings are essentially as effective as several light waterings. For maximum yields a plant should never show drought stress. Apply little, if any, water after the grain is in the dough stage. Excessive moisture at this time encourages head branching and tillering and prevents the plants from drying properly for harvest. Lodging is often a problem if soil-moisture supplies are completely depleted before the crop is mature.

When fertilizers are applied it may be necessary to irrigate early so that the nutrients are available to the young growing plants. Soils low in fertility utilize water better when fertilizers are applied. For maximum yields, irrigation and fertilization must be in proper balance.

Irrigation of most grain sorghum in the Great Plains States is done in graded furrows; but level furrows, level borders, graded borders, and sprinklers are sometimes used. Gated pipes are popular for furrow irrigation in some areas because they eliminate considerable ditching, prevent ditchbank erosion, and control the water.

HARVESTING, DRYING, AND STORING

Harvesting

Nearly all the grain sorghum crop is harvested with a combine (fig. 4). Only the small acreage of tall, dual-purpose types is headed by hand or harvested with corn binder, shocked, and threshed. In the central and northern Great Plains nearly all the crop is harvested after frost. In the other major grain sorghum producing regions, where the growing season is longer, combining is done as soon as the crop is ripe.

Sorghum grain threshes free from the head when the moisture content is 25 to 30 percent; but the moisture content must be low at harvest because sorghum grain does not dry well in the bin. A moisture content of under 13 percent in the Great Plains and of 11 percent in the South is necessary for safe stor-

FIGURE 4.—Combining a high-yielding field of grain sorghum after a killing frost in the central Great Plains.

age. Varieties and hybrids, such as the Martin variety, having a head stem that dries out soon after the grain is mature are popular because they can be harvested early in the fall. The harvesting of varieties with green head stems must wait generally until a light frost of 26° F. or lower has killed the top of the plant.

Usually the moisture content of the grain is low enough for safe storage after a week of drying weather following such a frost. Small bits of stems in the grain are usually high in moisture. Remove these before storing the grain.

Combines do excellent threshing when the cylinder speed and concave clearance are adjusted to allow a minimum of cracking. Distinct varietal differences exist in the brittleness of seed. Combine 7078 and Midland crack easily.

Ordinary varieties and hybrids of grain sorghum are short under dryland farming in most years, but they attain considerable height under irrigation or in wet seasons. Since the heads are harvested as high as possible, types that have heads well extended above the leaves are preferred. Small heads are easier to combine.

Drying

Wet grain, either from the combine or from the bin after storage, can best be handled by air drying. Unheated air can be used if the grain is not too damp or the humidity too high. But with damp grain or high humidity, more air must be moved through the grain and drying operations may have to be limited to the drier parts of the day. Hot-air driers are increasing in number, as they allow harvesting of the crop before the onset of winter weather and before many of the stalks are lodged. If the grain is to be fed, it must not be heated over

200° F. as some food value may be lost because of oxidation. If it is to be milled, it must not be heated over 140° as the starch may be modified. If it is to be used for seed, it must not be heated over 110° as the germs probably would be killed.

Small amounts of sorghum grain can be dried by spreading in thin layers. This works best in the less humid areas. Normally a fan and duct arrangement for forced unheated air is relatively inexpensive.

In years of high grain production in the Plains States, storage facilities are usually insufficient. As a result, much of the grain is piled on the ground for a short period after harvest. The grain dries considerably in these piles. Piling the grain on clean ground has been more successful than placing the pile on canvas, on wood, or on a concrete surface because less moisture accumulates at the bottom.

Storing

Storage normally is not difficult in the dry areas, where grain sorghum is best adapted; but in the humid areas, limit storage primarily to the winter months if the grain has not been dried artificially. Check the grain in bins frequently. A musty smell or a clumping of the grain indicates excessive moisture content.

Thoroughly clean the bins before storing sorghum grain. Sweep the floors and walls and then spray with a satisfactory insecticide, such as 5-percent methoxychlor. Remove seed residues and feed sacks from in and around the bins.

Fumigation will control insect infestation that may occur after prolonged storage. Take the necessary precautions against inhalation of fumes and fire risks. Generally, grain sorghum needs higher dosages of fumigants than does wheat because the grain packs together more closely.

UTILIZATION

Feeding Grain Sorghum

Grain sorghum is similar chemically to corn. It averages about 2 percent higher in protein and 1 percent lower in fat. The amino acid content of grain sorghum is nearly the same as corn. Grain sorghum is particularly deficient in lysine for livestock. The fats in grain sorghum and corn are almost identical in composition. The mineral composition of corn and grain sorghum differs only slightly.

Ordinary grain sorghum, even that with colored seedcoats, is like white corn in that it contains practically no vitamin A (carotenoid pigments). Recently true yellow endosperm grain sorghums have been derived from foreign stocks with less than half the carotenoid pigments of yellow corn. Yellow pigment dissipates much more rapidly from sorghum grain in the field than from corn, and considerable vitamin A has been lost by the time the crop is fed. Breeders are attempting to develop grain sorghum varieties with a good vitamin A content. Grain sorghum is higher in niacin, one of the B vitamins, than is corn.

Differences in chemical composition between varieties are slight as compared with those caused by environment. Grain sorghum grown in dry areas and in dry years invariably is significantly higher in protein than the same varieties grown in humid areas or under irrigation. Grain sorghum hybrids have averaged ½ to 1 percent lower in protein content than varieties grown under the same conditions; this is probably a result of increased yields.

Feeding experiments show that grain sorghum and corn are equal or about equal in feeding value. The two feeds were identical in value for laying hens and for boiler production. Grain sorghum

equaled or nearly equaled corn for fattening lambs and for milk production of dairy animals. On the average grain sorghum was only about 95 percent as valuable as corn for beef animals and 90 percent for fattening hogs. However, hogs gained slightly faster with a mixture of one-third corn and two-thirds grain sorghum than when corn was the only grain fed. All values are based on feed requirements per unit of gain. The lower value of grain sorghum for fattening hogs and beef is attributed to the difference in fat and perhaps in the balance of the amino acids. Other unknown differences may exist.

Grain sorghum, in general, is highly palatable to livestock. However, some varieties with dark-colored grains are somewhat bitter in taste. This bitterness is not necessarily associated with tannin content. When feeding varieties that differ in taste, feed the least preferred variety first. External conditions can influence palatability; for example, weathering before harvest causes molding. For best results, the grain should be ground, cracked, or preferably rolled for cattle. Grinding grain is not economical if self-fed to hogs or sheep, although unthreshed heads should be ground when fed to sheep. Sorghum grain is fed to poultry whole, cracked in scratch feed mixtures, or ground in mash.

Grain sorghums are a carbohydrate feed and should be fed generally in rations supplemented with protein. Despite a slightly lower feeding value for some purposes than corn, grain sorghum is usually the more economical feed when purchased. In the low-rainfall areas where it is adapted, the acre value of grain sorghum on both irrigated and nonirrigated land exceeds that of corn because of its higher yield. In the higher rainfall areas the dollar value will be lower.

Increasingly more high-moisture grain (around 25 percent) is being ensiled and fed to livestock direct from the silo. The grain will keep well if protected from contact with air. Ensiling wet grain utilizes the crop with a minimum of harvest and storage hazards.

Pasturing cattle or sheep on grain sorghum stubble utilizes roughage and dropped heads that might otherwise be wasted (fig. 5). Grain varieties, such as Midland, that have juicy stalks and leaves are particularly valued for grazing. The pastured plants must be mature with no new secondary growth to avoid prussic acid poisoning. Grain sorghum stubble available in dry years when grain yields are low is preferred to corn stubble by livestock because of a higher concentration of carbohydrates, particularly sugars, in the stems. In the Great Plains grazed fields are more subject to winter and early-spring wind erosion than are combined fields with standing stalks.

Industrial Utilization

Most of the grain sorghum grown in the United States is fed to livestock, but about 7 million bushels annually are milled for starch or flour. Both wet- and dry-milling are employed, utilizing both waxy (glutinous) and ordinary grain. The major use of the starch flour is in building materials, primarily wallboard; minor uses are in sizings, adhesives, and oil well drilling muds. Important byproducts are livestock feed and oil. Some starch is converted to dextrose by hydrolysis and is then used in the fruit-canning industry or in confections.

During World War II considerable grain sorghum was made into industrial alcohol and waxy sorghum starch was substituted for tapioca. Research to develop new industrial uses of grain sorghum is underway.

FIGURE 5.—Cattle grazing on grain sorghum stubble. Grazing efficiently utilizes stalks, leaves, and dropped heads.

DISEASES AND THEIR CONTROL [3]

The diseases attacking grain sorghums may be classified as seed rots and seedling blights, leaf diseases, smuts, root rots, and stalk rots.

Seed Rots and Seedling Blights

Seed rots and seedling blights are most severe when the soil is wet and cold after the seed is planted. Under such conditions, much of the seed fails to germinate because it is attacked by various seedborne and soil-inhibiting fungi that soon rot it. These rots can be controlled most effectively by selecting sound seed free from cracks, by treating the seed, and by planting after the soil temperatures are 70° F. or higher.

Leaf Diseases

Leaf diseases are generally destructive only in areas having a high rainfall and high humidity. The three bacterial diseases, bacterial stripe, bacterial streak, and bacterial spot, are often present but usually do not cause serious losses. During warm, moist seasons they may spread rapidly from the lower to the upper leaves until they destroy much of the leaf surface. The fungus leaf diseases include rough spot, anthracnose, leaf blight, zonate leaf spot, gray leaf spot, target spot, sooty stripe, and rust. These diseases are common on grain sorghums in the United States, but they seldom are of economic importance except in the South.

Smuts

Sorghum smuts are not poisonous to livestock, and affected grain sorghum can be fed without harmful effects. Covered kernel smut can cause serious yield losses if the seed is not treated. Loose kernel smut is similar to covered kernel smut except that the galls in the infected heads are longer and more frequently broken. This smut is rarely found. Seed treatment controls it.

[3] For further information, see U.S. Dept. Agr. Farmers' Bul. 1959, Sorghum Diseases and Their Control.

Head smut attacks the heads, usually destroying them and leaving only a mass of spores. Occasionally the head of an infected plant may be sterile, and the smut galls will later appear on the heads produced on side branches or tillers. This disease is carried over in the soil, where it infects the young plants. Seed treatment does not control head smut. The use of resistant varieties may be the only feasible means of control.

Root and Stalk Rots

The most important root and stalk diseases of grain sorghums are periconia root rot (milo disease), weak neck, and several stalk rots.

Periconia root rot attacks milo and darso, but it does not injure other grain sorghums. Most varieties in commercial production are resistant to the disease. When susceptible varieties are grown on diseased soil, the seedlings may die soon after emergence; or their death may be delayed, and they may have the appearance of having been killed by drought.

Weak neck is a nonparasitic disease. Combine grain varieties that produce heavy heads but have a weak head stem that dries when the grain ripens often develop a rot at the base of the head stem within the boot, where moisture accumulates. Bacteria and fungi cause the rotting, and the stem is weakened so that the heads break over during high winds.

Charcoal rot is a disease that attacks the stalk as the plant nears maturity. The pith dries and disintegrates so that the stalk is weakened and finally breaks at the base. A few varieties are partly resistant to charcoal rot, and this offers the principal hope of control. Charcoal rot is most serious when the plants suffer from a shortage of soil moisture.

Fusarium stalk rot produces symptoms similar to charcoal rot, but the spores in the rotted stalks are white instead of black. The fungus apparently enters the plant through openings made by insects and mechanical injuries. Fusarium rot is commonly found as a secondary infection in diseased plants.

Rhizoctonia stalk rot differs from charcoal rot in that the vascular fibers appear as light streaks in a reddish discolored pith. The fruiting bodies are brown instead of black and appear on the outside of the stalk instead of inside.

INSECTS AND THEIR CONTROL [4]

Several species of insects attack grain sorghums. Some of the most important include grasshoppers, corn earworm, corn leaf aphid, sorghum midge, sorghum webworm, and chinch bug.

Grasshoppers

Grasshoppers frequently do considerable damage to grain sorghums. If very abundant, they strip the leaves from the plant and feed on the heads.

Protect fields from grasshopper injury by destroying the young nymphs in adjacent field margins, ditchbanks, or wastelands with an insecticide before they move into the grain sorghums.

Proper tillage in the fall and spring, if in conformance with good soil conservation practices, will destroy many grasshopper eggs and reduce subsequent infestation in the vicinity.

Corn Earworm

The corn earworm is found throughout the grain sorghum area. The larvae feed in the leaf whorl and on the developing head. Varieties with open heads give some protection from this insect.

[4] Contributed by Entomology Research Division.

Corn Leaf Aphid

The corn leaf aphid is sometimes very common on grain sorghums throughout the central and southern Great Plains. It is usually found in the central whorl or on the panicle after it has emerged. Occasionally it is so abundant that it prevents the formation of grain. No cultural control of the aphid is effective.

Sorghum Midge

The sorghum midge sometimes prevents the profitable production of grain sorghums in the more humid areas. The adults lay their eggs in the flowers, and the larvae from them suck the juices from the developing seed.

Locate fields of grain sorghum as far as possible from outside sources of infestation, such as johnsongrass or older fields of grain sorghum. To reduce the possibility of damage, time planting so that the plants will come into bloom when the adult insects are not abundant in the fields.

Sorghum Webworm

The sorghum webworm is often abundant in the eastern part of the grain sorghum area. When abundant, this insect may destroy the developing grain. Destruction of plant residues and early planting are cultural aids.

Chinch Bug

The chinch bug in some years is a serious pest of grain sorghums. The first-generation eggs are laid in fields of small grain, where the young nymphs feed. As the grain ripens the older nymphs and adults migrate to nearby corn or grain sorghums. They suck juice from the plants, which weakens and sometimes kills the plants. To reduce chinch bug injury, plant early and as far as possible from infested small grains.

Other Insect Pests

Several other insects sometimes injure grain sorghums. Among them are southwestern corn borer, lesser cornstalk borer, European corn borer, flea beetle, stinkbug, fall armyworm, white grub, and various species of ants.

For further information regarding the control of insect pests of grain sorghums, consult your State agricultural experiment station or the Entomology Research Division, Agricultural Research Service, United States Department of Agriculture, Beltsville, Md.[5]

[5] Also see U.S. Dept. Agr. Handb. 120, Insecticide Recommendations.

CAUSAL ORGANISMS OF SORGHUM DISEASES

Common name	*Causal organism*
Anthracnose	*Colletotrichum graminicolum* (Ces.) G. W. Wis.
Bacterial spot	*Pseudomonas syringe* Van Hall
Bacterial streak	*Xanthomonas holcicola* (C. Elliott) Starr & Burk
Bacterial stripe	*Pseudomonas andropogoni* (E. F. Sm.) Stapp
Charcoal rot	*Macrophimona phaseoli* (Maub.) Ashby
Covered kernel smut	*Sphacelotheca sorghi* (Lk.) Clint.
Fusarium stalk rot	*Fusarium moniliforme* Sheldon
Gray leaf spot	*Cercospora sorghi* Ell. & Ev.
Head smut	*Sphacelotheca reiliana* (Kuehn) Clint.
Leaf blight	*Helminthosporium turcicum* Pass.
Loose kernel smut	*Sphacelotheca cruenta* (Kuehn) Potter
Milo disease	*Periconia circinata* (Mang.) Sacc.
Rhizoctonia stalk rot	*Rhizoctonia solani* Kuehn
Rough spot	*Ascochyta sorghina* Sacc.
Rust	*Puccinia purpurea* Cke.
Sooty stripe	*Ramulispora sorghi* (Ell. & Ev.) Olive & Lefebvre
Target spot	*Helminthosporium sorghicola* Lefebvre & Sherwin
Zonate leaf spot	*Gleocercospora sorghi* D. Bain & Edg.

COMMON AND SCIENTIFIC NAMES OF INSECTS THAT ATTACK SORGHUM

Common name	*Scientific name*
Chinch bug	*Blissus leucopterus* (Say)
Corn earworm	*Heliothis zea* (Boddie)
Corn leaf aphid	*Rhopalosiphum maidis* (Fitch)
European corn borer	*Pyrausta nubilalis* (Hbn.)
Fall armyworm	*Laphygma frugiperda* (J. E. Smith)
Lesser cornstalk borer	*Elasmopalpus lignosellus* (Zell.)
Sorghum midge	*Contarinia sorghicola* (Coq.)
Sorghum webworm	*Celama sorghiella* (Riley)
Southwestern corn borer	*Zeadiatraea grandiosella* (Dyar)

PRECAUTIONS

Fungicides and insecticides are poisonous. Use them only when needed and handle them with care. Follow the directions and heed all precautions on the container label. Insecticides and fungicides should be kept in closed, well-labeled containers in a dry place where they will not contaminate food or feed, and where children and pets cannot reach them. To protect fish and wildlife, do not contaminate streams, lakes, or ponds with fungicides and insecticides. Do not clean spraying equipment or dump excess spray material near such water. Do not feed treated seed to livestock.

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